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METHOD AND DEVICE FOR REPLACEMENT OF NUCLEAR REACTOR PRESSURE VESSEL

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METHOD AND DEVICE FOR REPLACEMENT OF NUCLEAR REACTOR PRESSURE VESSEL

[Genshiro atsuryoku yoki torikae hoho oyobi sochi]

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[There are no amendments to this patent.]

Claims

1. A method for replacement of a nuclear reactor pressure vessel characterized by the following facts: after the fuel and inner structural parts are removed from the nuclear reactor pressure vessel and transferred to a maintenance building for storage, equipment for removing the nuclear reactor pressure vessel is set above the nuclear reactor building; an opening is formed

* [Numbers in the margin indicate pagination in the foreign text.]

on the roof of the nuclear reactor building; from the opening, said nuclear reactor pressure vessel is removed; on the other hand, a new nuclear reactor pressure vessel is installed through the opening of said roof; then, the fuel and inner structural parts are transferred from said maintenance building back into the nuclear reactor pressure vessel for reloading.

2. A method for replacement of a nuclear reactor pressure vessel characterized by the following facts: after the fuel and inner structural parts are removed from the nuclear reactor pressure vessel and transferred to a maintenance building for storage, equipment for removing the nuclear reactor pressure vessel is set above the nuclear reactor building; an opening is formed on the roof of the nuclear reactor building; the pressure vessel and heat shielding body of nuclear reactor are sequentially removed; from the opening on the other hand, a new heat shielding body and a new nuclear reactor pressure vessel are installed through the opening of said roof; then, the fuel and inner structural parts are transferred from said maintenance building back into the nuclear reactor pressure vessel for reloading.

3. The method for replacement of nuclear reactor pressure vessel described in Claim 2, characterized by the fact that the inner diameter of the new heat shielding body is selected to be larger than the outer diameter of the nozzle portion of the new nuclear reactor pressure vessel.

4. The method for replacement of nuclear reactor pressure vessel described in Claim 1, characterized by the following facts: after the nuclear reactor pressure vessel is removed, the control rod driving device's handler is removed from the opening on the roof; then the pedestal is remodeled and a new internal pump/control rod driving device's handler is installed through the opening on said roof.

5. The method for replacement of nuclear reactor pressure vessel described in Claim 1, characterized by the fact that the nuclear reactor pressure vessel is of a type corresponding to a circulating system utilizing an internal pump.

6. The method for replacement of nuclear reactor pressure vessel described in Claim 1, characterized by the following facts: after the nuclear reactor pressure vessel is removed, the internal pump/control rod driving device's handler is removed from the opening on the roof; then, a new internal pump/control rod driving device's handler is installed through the opening on said roof.

7. A method for replacement of nuclear reactor pressure vessel characterized by the following facts: after the fuel and inner structural parts are removed from the nuclear reactor pressure vessel and transferred to a maintenance building for storage, equipment for removing the nuclear reactor pressure vessel is set above the nuclear reactor building; from an opening formed on the roof of the nuclear reactor beforehand, said nuclear reactor pressure vessel is removed; on the other hand, a new nuclear reactor pressure vessel is installed through the

opening of said roof; then, the fuel and inner structural parts are transferred from said maintenance building back into the nuclear reactor pressure vessel for reloading.

8. A device for replacement of nuclear reactor pressure vessel characterized by the following facts: the device has the following parts: a frame set straddling the nuclear reactor building, accommodating equipment carried on the frame and connected by a third air lock to a removal chamber with a first air lock mounted on the upper side and a hoisting chamber with a second air lock mounted on the lower side, a crane which is set on the ceiling surface of said hoisting chamber and which hoists the nuclear reactor pressure vessel from said nuclear reactor building to the hoisting chamber, a flatcar which moves on the floor of said removal chamber and hoisting chamber, a tower crane which is carried on said frame and which lowers the nuclear reactor pressure vessel transferred to said removal chamber to outside said accommodating equipment, and a running flatcar which runs to transfer the nuclear reactor pressure vessel lowered by said tower crane to the maintenance building; while the nuclear reactor pressure vessel is removed from said nuclear reactor building to the maintenance building for disassembly, cleaning of pollution, repair, and storage, a new replacement nuclear reactor pressure vessel is lowered in and installed in said nuclear reactor building.

9. The device for replacement of nuclear reactor pressure vessel described in Claim 8, characterized by the fact that the accommodating equipment is made of a hoisting-up chamber alone.

10. The device for replacement of nuclear reactor pressure vessel described in Claim 8, characterized by the fact that the accommodating equipment is made of a hoisting-up chamber alone, and the tower crane is changed to a frame set on the ground surface.

11. The device for replacement of nuclear reactor pressure vessel described in Claim 10, characterized by the fact that a crawler crane is used instead of a tower crane.

12. The device for replacement of nuclear reactor pressure vessel described in Claim 8, characterized by the fact that the accommodating equipment is made of a hoisting-up chamber alone, and the flatcar has a structure that allows it to move from one end of the frame to the other end.

13. The device for replacement of nuclear reactor pressure vessel described in Claim 8 or 12, characterized by the fact that the flatcar moving on the frame is equipped with a pneumatic float-up-type moving device.

14. The device for replacement of nuclear reactor pressure vessel described in Claim 12, characterized by the following facts: the hoisting-down[sic; hoisting-up] chamber has an air dome structure; a gantry structural body is set inside it; and the crane for hoisting the nuclear reactor pressure vessel is mounted on the gantry structural body.

15. The device for replacement of nuclear reactor pressure vessel described in Claim 8 or 14, characterized by the fact that the frame is of a running type, and the nuclear reactor pressure vessel is carried directly on the running flatcar by a crane mounted on the gantry structural body.

16. A device for replacement of nuclear reactor pressure vessel characterized by the following facts: the device has the following parts: a crawler crane which hoists the nuclear reactor pressure vessel from a nuclear reactor building set on the ground surface, a simple accommodating equipment which is set in said nuclear reactor building and has the nuclear reactor pressure vessel hoisted into it, and a running flatcar which directly carries the simple accommodating equipment with the nuclear reactor pressure vessel joined to it by said crawler crane from the nuclear reactor building and transfers it to the maintenance building; while the nuclear reactor pressure vessel is removed from said nuclear reactor building to the maintenance building for disassembly, cleaning of pollution, repair, and storage, a new nuclear reactor pressure vessel for replacement is lowered in and installed in said nuclear reactor building.

Detailed explanation of the invention

[0001]

Industrial application field

/3

This invention pertains to a nuclear plant that has entered the stage of power generation. In particular, this invention pertains to a method and a device for replacement of nuclear reactor pressure vessel, characterized by the fact that in order to ensure the long-term safety of the nuclear plant, the nuclear reactor pressure vessel is removed from the nuclear reactor building and, in a maintenance building set within the perimeter of the power plant, the nuclear reactor pressure vessel is cleaned to get rid of pollution, disassembled, and stored; and, on the other hand, a new nuclear reactor pressure vessel for replacement is lowered in and installed in said nuclear reactor building.

[0002]

Prior art

Nuclear power plants are usually designed to have a lifetime of 30 or 40 years. However, not all of the equipment in the plant has the same lifetime. If the nuclear reactor pressure vessel, which is the main equipment of the plant, is replaced in a timely manner by a new nuclear reactor pressure vessel, it is possible to prolong the lifetime of the nuclear power plant and to reduce the total amount of the waste generated. This method has become attractive.

[0003]

Problems to be solved by the invention

When the nuclear reactor pressure vessel that has started power generation is removed from the nuclear reactor building or when a new nuclear reactor pressure vessel is installed into the nuclear reactor building, it is necessary to ensure that no radioactive substance leaks from the nuclear reactor building to outside the building.

[0004]

When the nuclear reactor pressure vessel is removed from the nuclear reactor building, one may adopt a method by which the nuclear reactor pressure vessel is cut into small sections inside the nuclear reactor building and the sections are removed from the large-part access port, and then the members of the new nuclear reactor pressure vessel are installed through the large-part access port and are assembled inside the nuclear reactor building. In this case, no radioactive substance is released outside the building as the nuclear reactor pressure vessel is replaced. On the other hand, however, the nuclear power plant has to be shut off for a long time. This is a disadvantage.

[0005]

Consequently, there is a demand to perform replacement of the nuclear reactor pressure vessel without shutting off the nuclear power plant for a long time. For this purpose, it is necessary to install an inlet equipped with air locks that allows removal/replacement of the nuclear reactor pressure vessel as a single body after the building stage of the nuclear power plant, and it is necessary to install it as a new part while the plant is in operation.

[0006]

In consideration of the difficulty in transferring the nuclear reactor pressure vessel as a heavy member, it is preferred that the access port be set on the roof of the nuclear reactor building right above the nuclear reactor pressure vessel. In the design of the roof of a conventional nuclear reactor building, only the strength for withstanding snow deposition is taken into consideration. Consequently, in order to install an inlet structure equipped with air locks on the roof, it is necessary to change the concept of construction of the building or to adopt other means.

[0007]

When the disposed nuclear reactor pressure vessel is processed using a conventional waste processing method, it is divided into small sections which are enclosed in containers for

storage. In this case, however, the dividing operation needs significant labor, and it is necessary to process any radioactive powder generated in the dividing operation. Also, as the nuclear reactor pressure vessel is a strong structural member, if it is used as a vessel for storing the radioactive substance, it is possible to omit the dividing operation and the operation for processing the fine radioactive powder generated in the dividing operation. Consequently, it is necessary to consider a method of using the used nuclear reactor pressure vessel as a waste-storing vessel.

[0008]

When the used nuclear reactor pressure vessel is used as a waste-storing vessel by removing pollution and maintaining the surface of the nuclear reactor pressure vessel, it is possible to prevent diffusion of the radioactive substance from the nuclear reactor pressure vessel during storage, and it is necessary to perform volume reduction operations as well as pollution elimination and disassembly operations for the internal structural parts stored in the nuclear reactor pressure vessel. In order to reduce exposure to radiation, these operations are carried out as remote operations by means of various automatic equipment and robots. However, in order to use this remote operation equipment effectively, it is believed necessary to perform the operation in a factory automation (FA) plant or other maintenance building.

[0009]

When an operation is performed to take the nuclear reactor pressure vessel integrally from/into the roof portion of the nuclear reactor building, from a safety viewpoint it is preferred that the used fuel not be stored in the fuel storing pool. Consequently, it is necessary to consider a method for taking the used fuel from the fuel-storing pool to a fuel-storing facility outside the nuclear reactor building for storage.

[0010]

The purpose of this invention is to solve the aforementioned problems by providing a method and device for replacement of nuclear reactor pressure vessel, characterized by the fact that when the nuclear reactor pressure vessel is removed from/replaced in the nuclear reactor building as a single body, there is no need to give special consideration to reinforcement of the roof of the nuclear reactor building, emission of the radioactive substance from the nuclear reactor building can be prevented, and exposure of workers to radiation during the operation can be reduced.

[0011]

Means to solve the problems

In order to solve the aforementioned problems, Claim 1 of this invention provides a method for replacement of nuclear reactor pressure vessel characterized by the following facts: after the fuel and inner structural parts are removed from the nuclear reactor pressure vessel and transferred to a maintenance building for storage, equipment for removing the nuclear reactor pressure vessel is set above the nuclear reactor building; an opening is formed on the roof of the nuclear reactor building; from the opening, said nuclear reactor pressure vessel is removed; on the other hand, a new nuclear reactor pressure vessel is installed through the opening of said roof; then, the fuel and inner structural parts are transferred from said maintenance building back into the nuclear reactor pressure vessel for reloading.

[0012]

Claim 2 provides a method for replacement of nuclear reactor pressure vessel, characterized by the following facts: after the fuel and inner structural parts are removed from the nuclear reactor pressure vessel and transferred to a maintenance building for storage, equipment for removing the nuclear reactor pressure vessel is set above the nuclear reactor building; an opening is formed on the roof of the nuclear reactor building; from the opening, the pressure vessel and heat shielding body of the nuclear reactor are sequentially removed; on the other hand, a new heat shielding body and a new nuclear reactor pressure vessel are installed through the opening of said roof; then, the fuel and inner structural parts are transferred from said maintenance building back into the nuclear reactor pressure vessel for reloading.

[0013]

According to the method for replacement of nuclear reactor pressure vessel described in Claim 3, for the method described in Claim 2, the inner diameter of the new heat shielding body is selected to be larger than the outer diameter of the nozzle portion of the new nuclear reactor pressure vessel. According to the method for replacement of nuclear reactor pressure vessel described in Claim 4, for the method described in Claim 1, after the nuclear reactor pressure vessel is removed, the control rod driving device's handler is removed from the opening on the roof; then, the pedestal is remodeled, and a new internal pump/control rod driving device's handler is installed through the opening on said roof.

[0014]

According to the method for replacement of nuclear reactor pressure vessel described in Claim 5, for the method described in Claim 1, the nuclear reactor pressure vessel is of a type corresponding to a circulating system utilizing an internal pump.

[0015]

According to the method for replacement of nuclear reactor pressure vessel described in Claim 6, for the method described in Claim 1, after the nuclear reactor pressure vessel is removed, the internal pump/control rod driving device's handler is removed from the opening on the roof; then, a new internal pump/control rod driving device's handler is installed through the opening on said roof.

[0016]

According to the method for replacement of nuclear reactor pressure vessel described in Claim 7, after the fuel and inner structural parts are removed from the nuclear reactor pressure vessel and transferred to a maintenance building for storage, equipment for removing the nuclear reactor pressure vessel is set above the nuclear reactor building; from an opening formed beforehand on the roof of the nuclear reactor, said nuclear reactor pressure vessel is removed; on the other hand, a new nuclear reactor pressure vessel is installed through the opening of said roof; then, the fuel and inner structural parts are transferred from said maintenance building back into the nuclear reactor pressure vessel for reloading.

[0017]

According to the device for replacement of nuclear reactor pressure vessel described in Claim 8, the device has the following parts: a frame set straddling the nuclear reactor building, an accommodating equipment which is carried on the frame and which is connected by a third air lock to a removal chamber with a first air lock mounted on the upper side and a hoisting-up chamber with a second air lock mounted on the lower side, a crane which is set on the ceiling surface of said hoisting-up chamber and which hoists the nuclear reactor pressure vessel from said nuclear reactor building to the hoisting-up chamber, a flatcar which moves on the floor of said removal chamber and hoisting-up chamber, a tower crane which is carried on said frame and which lowers the nuclear reactor pressure vessel transferred to said removal chamber to outside said accommodating equipment, and a running flatcar which runs to transfer the nuclear reactor pressure vessel lowered by said tower crane to the maintenance building; while the nuclear reactor pressure vessel is removed from said nuclear reactor building to the maintenance building

for disassembly, cleaning of pollution, repair, and storage, a new nuclear reactor pressure vessel for replacement is lowered in and installed in said nuclear reactor building.

[0018]

According to the device for replacement of nuclear reactor pressure vessel described in Claim 9, for the device described in Claim 8, the accommodating equipment is made up of a hoisting-up chamber alone.

[0019]

According to the device for replacement of nuclear reactor pressure vessel described in Claim 10, for the device described in Claim 8, the accommodating equipment is made up of a hoisting-up chamber alone, and the tower crane is changed to a frame set on the ground surface.

[0020]

According to the device for replacement of nuclear reactor pressure vessel described in Claim 11, for the device described in Claim 10, a crawler crane is used instead of a tower crane.

[0021]

According to the device for replacement of nuclear reactor pressure vessel described in Claim 12, for the device described in Claim 8, the accommodating equipment is made up of a hoisting-up chamber alone, and the flatcar has a structure that allows it to move from one end of the frame to the other end.

[0022]

According to the device for replacement of nuclear reactor pressure vessel described in Claim 13, for the device described in Claim 8 or 12, the flatcar moving on the frame is equipped with a pneumatic float-up-type moving device.

[0023]

According to the device for replacement of nuclear reactor pressure vessel described in Claim 14, for the device described in Claim 12, the hoisting-up chamber has an air dome structure; a gantry structural body is set inside it; and the crane for hoisting the nuclear reactor pressure vessel is mounted on the gantry structural body.

[0024]

According to the device for replacement of nuclear reactor pressure vessel described in Claim 15, for the device described in Claim 8 or 14, the frame is of a running type and the nuclear reactor pressure vessel is carried directly on the running flatcar by a crane mounted on the gantry structural body.

[0025]

According to the device for replacement of nuclear reactor pressure vessel described in Claim 16, the device has the following parts: a crawler crane which hoists the nuclear reactor pressure vessel from a nuclear reactor building set on the ground surface, simple accommodating equipment which is set in said nuclear reactor building and has the nuclear reactor pressure vessel hoisted into it, and a running flatcar which directly carries the simple accommodating equipment with the nuclear reactor pressure vessel joined to it by said crawler crane from the nuclear reactor building and transfers it to the maintenance building; while the nuclear reactor pressure vessel is removed from said nuclear reactor building to the maintenance building for disassembly, cleaning of pollution, repair, and storage, a new nuclear reactor pressure vessel for replacement is lowered in and installed in said nuclear reactor building.

[0026]

Function

According to the method for replacement of nuclear reactor pressure vessel described in Claim 1 of this invention, after the fuel and inner structural parts are removed from the nuclear reactor pressure vessel and transferred to a maintenance building for storage, equipment for removing the nuclear reactor pressure vessel is set above the nuclear reactor building; an opening is formed on the roof of the nuclear reactor building; from the opening, said nuclear reactor pressure vessel is removed; on the other hand, a new nuclear reactor pressure vessel is installed through the opening of said roof; then, the fuel and inner structural parts are transferred from said maintenance building back into the nuclear reactor pressure vessel for reloading. Consequently, the nuclear reactor pressure vessel can be replaced in a short time free of diffusion of the radioactive substance to the surrounding [area], and after replacement the large structural members can be safely stored for a long time.

[0027]

According to the method for replacement of nuclear reactor pressure vessel described in Claim 2, from the opening, the pressure vessel and heat shielding body of the nuclear reactor are removed sequentially; on the other hand, a new heat shielding body and a new nuclear reactor

pressure vessel are installed through the opening of said roof. Consequently, it is possible to replace the nuclear reactor pressure vessel and heat shielding body in a short time free of diffusion of the radioactive substance to the surrounding [area].

[0028]

According to the method for replacement of nuclear reactor pressure vessel described in Claim 3, for the method described in Claim 2, the inner diameter of the new heat shielding body is selected to be larger than the outer diameter of the nozzle portion of the new nuclear reactor pressure vessel. Consequently, it is possible to further shorten the time of operation for taking the new heat shielding body as a single body into the nuclear reactor building for replacement.

[0029]

According to the method for replacement of nuclear reactor pressure vessel described in Claim 4, for the method described in Claim 1, after the nuclear reactor pressure vessel is removed, the control rod driving device's handler is removed from the opening on the roof; then, the pedestal is remodeled and a new internal pump/control rod driving device's handler is installed through the opening on said roof. Consequently, it is possible to change to a circulating system utilizing an internal pump with even higher safety, and it is possible to shorten the fuel exchange period. Also, it allows change to a nuclear reactor adopting a larger fuel size, thus it is possible to improve the safety and operational efficiency of the nuclear power plant. /5

[0030]

According to the method for replacement of nuclear reactor pressure vessel described in Claim 5, for the method described in Claim 1, the nuclear reactor pressure vessel is of a type corresponding to a circulating system utilizing an internal pump. Consequently, it is possible to perform the change needed for increasing the efficiency of the internal pump so that the safety and economy can be improved.

[0031]

According to the method for replacement of nuclear reactor pressure vessel described in Claim 6, for the method described in Claim 1, after the nuclear reactor pressure vessel is removed, the internal pump/control rod driving device's handler is removed from the opening on the roof; then, a new internal pump/control rod driving device's handler is installed through the opening on said roof. In this way the functions described in both Claim 1 and 4 can be realized.

[0032]

According to the method for replacement of nuclear reactor pressure vessel described in Claim 7, after the fuel and inner structural parts are removed from the nuclear reactor pressure vessel and transferred to a maintenance building for storage, equipment for removing the nuclear reactor pressure vessel is set above the nuclear reactor building; from an opening formed beforehand on the roof of the nuclear reactor, said nuclear reactor pressure vessel is removed; on the other hand, a new nuclear reactor pressure vessel is installed through the opening of said roof; then, the fuel and inner structural parts are transferred from said maintenance building back into the nuclear reactor pressure vessel for reloading. Consequently, in the replacement operation there is no need to set an opening portion on the roof of the nuclear reactor building. As a result, the number of operational steps is reduced and the operational period is shortened.

[0033]

According to the device for replacement of nuclear reactor pressure vessel described in Claim 8, the device has the following parts: a frame set straddling the nuclear reactor building, accommodating equipment which is carried on the frame and which is connected by a third air lock to a removal chamber with a first air lock mounted on the upper side and a hoisting-up chamber with a second air lock mounted on the lower side, a crane which is set on the ceiling surface of said hoisting-up chamber and which hoists the nuclear reactor pressure vessel from said nuclear reactor building to the hoisting-up chamber, a flatcar which moves on the floor of said removal chamber and hoisting-up chamber, a tower crane which is carried on said frame and which lowers the nuclear reactor pressure vessel transferred to said removal chamber to outside said accommodating equipment, and a running flatcar which runs to transfer the nuclear reactor pressure vessel lowered by said tower crane to the maintenance building; while the nuclear reactor pressure vessel is removed from said nuclear reactor building to the maintenance building for disassembly, cleaning of pollution, repair, and storage, a new nuclear reactor pressure vessel for replacement is lowered in and installed in said nuclear reactor building. Consequently, when the nuclear reactor pressure vessel is removed from/replaced in the nuclear reactor building as a single body, there is no need to give special consideration to reinforcement of the nuclear reactor building. It is possible to prevent emission of the radioactive substance from the nuclear reactor building, and the exposure to radiation during operations can be reduced.

[0034]

According to the device for replacement of nuclear reactor pressure vessel described in Claim 9, for the device described in Claim 8, the accommodating equipment is made up of a hoisting-up chamber alone. Consequently, there is no need to perform the operation for

opening/closing the first air lock of the hoisting-out chamber, and the operation period needed for replacement of the nuclear reactor pressure vessel can be shortened.

[0035]

According to the device for replacement of nuclear reactor pressure vessel described in Claim 10, for the device described in Claim 8, the accommodating equipment is made up of a hoisting-up chamber alone, and the tower crane is changed to a frame set on the ground surface. Consequently, in addition to the function of Claim 9, the operation for setting the tower crane becomes easier.

[0036]

According to the device for replacement of nuclear reactor pressure vessel described in Claim 11, for the device described in Claim 10, a crawler crane is used instead of a tower crane. Consequently, the same function as Claim 10 can be realized.

[0037]

According to the device for replacement of nuclear reactor pressure vessel described in Claim 12, for the device described in Claim 8, the accommodating equipment is made of a hoisting-up chamber alone, and the flatcar has a structure that allows it move from one end of the frame to the other end. Consequently, in addition to the function of Claim 9, the operational range of the tower crane can be made narrower and the size of the equipment needed can be reduced.

[0038]

According to the device for replacement of nuclear reactor pressure vessel described in Claim 13, for the device described in Claim 8 or 12, the flatcar moving on the frame is equipped with a pneumatic float-up-type moving device. Consequently, movement of the flatcar becomes easier.

[0039]

According to the device for replacement of nuclear reactor pressure vessel described in Claim 14, for the device described in Claim 12, the hoisting-up chamber has an air dome structure; a gantry structural body is set inside it; and the crane for hoisting the nuclear reactor pressure vessel is mounted on the gantry structural body. Consequently, handling becomes simpler, the system becomes lighter, and the frame becomes smaller.

[0040]

According to the device for replacement of nuclear reactor pressure vessel described in Claim 15, for the device described in Claim 8 or 14, the frame is of a running type, and the nuclear reactor pressure vessel is carried directly on the running flatcar by a crane mounted on the gantry structural body.

[0041]

According to the device for replacement of nuclear reactor pressure vessel described in Claim 16, the device has the following parts: a crawler crane which hoists the nuclear reactor pressure vessel from a nuclear reactor building set on the ground surface, simple accommodating equipment which is set in said nuclear reactor building and has the nuclear reactor pressure vessel hoisted into it, and a running flatcar which directly carries the simple accommodating equipment with the nuclear reactor pressure vessel joined to it by said crawler crane from the nuclear reactor building and transfers it to the maintenance building; while the nuclear reactor pressure vessel is removed from said nuclear reactor building to the maintenance building for disassembly, cleaning of pollution, repair, and storage, a new nuclear reactor pressure vessel for replacement is lowered in and installed in said nuclear reactor building. Consequently, the nuclear reactor pressure vessel can be removed directly from the nuclear reactor building, and there is thus no need to have equipment for hoisting and moving the nuclear reactor pressure vessel by means of the frame. As a result, the preparation period for constructing the equipment can be cut.

[0042]

Application examples

Application Example 1 (with respect to method and device) /6

Figure 1 is a flow chart illustrating in detail the various operation steps in Application Example 1 of the method for replacement of nuclear reactor pressure vessel in this invention. Figures 2-9 are flow chart diagrams illustrating in more detail the operation steps shown in Figure 1. Figure 10 is a diagram illustrating the configuration of Application Example 1 of the device for replacement of nuclear reactor pressure vessel in this invention.

[0043]

As shown in Figure 10, in this application example, frame (2) is set straddling nuclear reactor building (1). On said frame (2), accommodating equipment (8) equipped with air locks (3), (4) and (5), flatcar (6), crane (7), etc. is carried. Said accommodating equipment (8) and opening portion (10) of roof (9) on reactor building (1) are bound to each other in an air-tight

seal. Also, tower crane (11) is carried on frame (2). This equipment is used in performing the following remote operations: removal of nuclear reactor pressure vessel (12) from nuclear reactor building (1); setting it on flatcar (13) which runs on the ground surface; moving said flatcar (13) into maintenance building (14); transporting nuclear reactor pressure vessel (12) into operation pit (15) set in said maintenance building (14) to perform disassembly, cleaning of pollution, dissection, repair, maintenance operation, etc. On the other hand, new nuclear reactor pressure vessel (12) for replacement is set inside nuclear reactor building (1) through accommodating equipment (8).

[0044]

That is, on frame (2) set straddling nuclear reactor building (1), accommodating equipment (8) and tower crane (11) are carried. By means of flatcar (13) that runs on the ground surface, nuclear reactor pressure vessel (12) is transported from nuclear reactor building (1) to maintenance building (14) to perform the various operations of disassembly, cleaning of pollution, dissection, repair, maintenance operation, etc., while new nuclear reactor pressure vessel (12) for replacement is installed in nuclear reactor building (1).

[0045]

Accommodating equipment (8) is comprised of hoisting-up chamber (16) and hoisting-out chamber (17). The two chambers are connected to each other via air lock (4) (third air lock). Also, flatcar (6) with nuclear reactor pressure vessel (12), etc. carried on it can run freely on the floors of both chambers. On said flatcar (6), a supporting device (not shown in the figure) for holding nuclear reactor pressure vessel (12) is mounted. Air lock (5) (the second air lock) is attached on the lower surface of hoisting-up chamber (16), and it is bound in an air-tight seal to opening portion (10) of roof (9) of nuclear reactor building (1). Also, crane (7) for hoisting nuclear reactor pressure vessel (12) is mounted on the ceiling surface of hoisting up chamber (16). Air lock (3) (the first air lock) is mounted on the upper surface of hoisting-out chamber (17).

[0046]

In maintenance building (14), operation chamber (19) for performing such operations as disassembly, cleaning of pollution, dissection, repair, maintenance operation, etc. for nuclear reactor pressure vessel (12) is set. In said operation chamber (19), operation pit (15) and ceiling traveling crane (20) are set for loading nuclear reactor pressure vessel (12), and there is a water filling function in operation pit (15).

[0047]

Also, in maintenance building (14), there is fuel storing chamber (21) for temporary storage of the used fuel when the operation of replacement of nuclear reactor pressure vessel (12) is carried out. In Figure 10, the fuel transporting route from fuel storing loop (22) in nuclear reactor building (1) to fuel storing chamber (21) is not shown. In fuel storing chamber (21), fuel storing pit (23) and ceiling crane (24) are set.

[0048]

In the following, the operation procedure of the method for replacement of nuclear reactor pressure vessel in Application Example 1 will be explained with reference to Figure 1. As shown in Figure 1, first of all, in step S1, the nuclear plant is shut down. Then, in step S2, preparation is carried out for removal of nuclear reactor pressure vessel (12). In step S3, the operation for opening of roof (9) of nuclear reactor building (1) is performed. Then, in step S4, after nuclear reactor pressure vessel (12) is removed, heat shielding body (25) is removed (step S5). Then, in step S6, the new nuclear reactor pressure vessel is installed step S7, new heat shielding body (25) is assembled. In steps S8 and S9, various members in nuclear reactor pressure vessel (12) are assembled, and the equipment for removing nuclear reactor pressure vessel (12) is withdrawn. Then, the fuel is reloaded in the core of nuclear reactor pressure vessel (12) (steps S10, S11).

[0049]

Figure 2 is a diagram illustrating the operation procedure for preparing removal of the nuclear reactor pressure vessel in step S2 shown in Figure 1.

[0050]

As shown in Figure 2, in step S21, the head portion of nuclear reactor pressure vessel (12) and the upper lid of nuclear reactor pressure vessel (12) are removed in order. In step S22, the internal structural members are removed. In step S23, the fuel is transferred from the core to the fuel storing rack of fuel storing pool (22). From the fuel storing rack, the fuel is accommodated in a fuel transporting container, and, through a fuel transporting route, it is removed to fuel storing pit (23) of fuel storing chamber (21) in maintenance building (14) (step S24). Then, as all of the fuel in the core has been removed, the internal structural members are assembled in nuclear reactor pressure vessel (12) in step S25, and the upper lid is attached on nuclear reactor pressure vessel (12). In addition, in step S26, the equipment for removing the nuclear reactor pressure vessel is set above roof (9) of nuclear reactor building (1).

[0051]

Figure 3 is a diagram illustrating the operation procedure for opening the roof for the nuclear reactor pressure vessel in step S3 shown in Figure 1

[0052]

As shown in Figure 3, in step S31, temporary curing is performed on the upper surface of nuclear reactor well (26). Then, frame (2) is installed straddling nuclear reactor building (1). Accommodating equipment (8) is installed on said frame. Installation is carried out such that the center of air lock (5) on the lower surface of hoisting-up chamber (16) inside accommodating container (8) is positioned right above the central axis of nuclear reactor pressure vessel (12) set inside nuclear reactor building (1). Then, air lock (5) is opened, and the lower surface of hoisting-up chamber (16) and roof (9) of nuclear reactor building (1) are bound to each other in an air-tight seal (step S32). Then, the hoisting fixture is installed at the center of roof (9) corresponding to air lock (5), and crane (7), set on the ceiling of hoisting-up chamber (16), and said hoisting fixture are set in a hoisting state by wires (step S34). Roof (9) is cut for a size corresponding to the opening of air lock (5) by means of a laser cutter or the like (step S35).

[0053]

Upon the end of cutting and removal of a block of a size appropriate for passage of /7
nuclear reactor pressure vessel (12) from roof (9), the block is hoisted by crane (7) in hoisting-up chamber (16), and air lock (5) is closed. Then, air lock (4) is opened and flatcar (6) is moved from hoisting-out chamber (17) to hoisting-up chamber (16), and the block cut from roof (9) is lowered on flatcar (6) for curing. Then, flatcar (6) is moved to hoisting-out chamber (17) and air lock (4) is closed. After that, air lock (3) on the ceiling surface of hoisting-out chamber (17) is opened, the hook of tower crane (11) is lowered in hoisting-out chamber (17), the hoisting fixture of the block of roof (9) that had been removed and the hook of tower crane (11) are connected to each other by a wire, the block is hoisted out from hoisting-out chamber (17) and lowered onto flatcar (13) running on the ground surface. Said running flatcar (13) is driven into operation chamber (19) inside maintenance building (14) and, by means of ceiling running crane (20), the block cut out from roof (9) is lowered from running flatcar (13) to operation pit (15) or the like. Then, the aforementioned block is disassembled by a cutter or the like, and the obtained pieces are packed in a drum can for storage and are stored at a waste-storing site (step S36).

[0054]

Then, in a procedure reverse to that for removal of the block cut out from roof (9), a lid device that can be opened/closed is transported to opening portion (10) of roof (9) and is

installed on roof (9) (step S37). Then, in step S38, temporary curing is performed for the upper surface of nuclear reactor well (26).

[0055]

Figure 4 is a diagram illustrating the procedure of the operation for removing the nuclear reactor pressure vessel in step S4 shown in Figure 1.

[0056]

As shown in Figure 4, air lock (5) is opened, the open/close type lid device is opened, the hoisting fixture is mounted on the hook of crane (7) set on the ceiling surface of hoisting-up chamber (16) and is lowered into nuclear reactor building (1), and the hoisting fixture is bound to the lid of nuclear reactor pressure vessel (12) (step S41). Then, the pipeline connected to nuclear reactor pressure vessel (12) is cut at the nozzle portion (water is drained from nuclear reactor well (26) and nuclear reactor pressure vessel (12) before cutting), the blocking member between nuclear reactor pressure vessel (12) and the nuclear reactor accommodating container is withdrawn, and nuclear reactor pressure vessel (12) is cut off from pedestal (27) (steps S42-S44).

[0057]

Upon end of the operation for cutting nuclear reactor pressure vessel (12) from said pedestal (27), said nuclear reactor pressure vessel (12) is hoisted by crane (7) into hoisting-up chamber (16) and air lock (5) is closed. Then, air lock (4) is opened and flatcar (6) is moved from hoisting-out chamber (17) to hoisting-up chamber (16). Said nuclear reactor pressure vessel (12) is lowered onto flatcar (16) and the hoisting fixture is removed to perform curing. Said flatcar (6) is driven to hoisting-out chamber (17) and air lock (4) is closed. Then, air lock (3) on the ceiling surface of hoisting-out chamber (17) is opened, the hoisting fixture is mounted on the hook of tower crane (11), lowered into hoisting-out chamber (17), and bound to the lid of nuclear reactor pressure vessel (12). Then, nuclear reactor pressure vessel (12) is hoisted out from hoisting-out chamber (17) and lowered onto running flatcar (13) that runs on the ground surface (step S45).

[0058]

In step S46, running flatcar (13) is driven to operation chamber (19) inside maintenance building (14), nuclear reactor pressure vessel (12) is lowered from running flatcar (13) to operation pit (15) by means of ceiling crane (20), and it is fixated on the floor of operation pit (15) by a supporting device. Then, in step S47,water is filled in operation pit (15) and opening/closing of the upper lid of nuclear reactor pressure vessel (12) is carried out by means of

an automatic machine. Then, the welded internal structural members are cut in water by means of a cutter using a laser beam. The internal structural members are removed from nuclear reactor pressure vessel (12) and are transported in water into operation pit (28). When the interior of nuclear reactor pressure vessel (12) becomes empty, a laser beam is used to clean pollution from the surface of nuclear reactor pressure vessel (12). In this method of cleaning pollution by laser, it is especially effective to selectively remove cobalt 60, an isotope of cobalt, by means of the difference in the vapor pressure. Upon the end of cleaning of pollution of nuclear reactor pressure vessel (12), water gate (29) between operation pit (15) and operation pit (28) is closed, and water is exhausted from operation pit (15). Then, the lid is covered on the opening portion of the nozzle portion of nuclear reactor pressure vessel (12).

[0059]

Then, for the internal structural members temporarily set in operation pit (28), a laser beam is used to clean pollution and cutting to reduce the volume. After reduction of volume, the internal structural members are accommodated again in nuclear reactor pressure vessel (12), and nuclear reactor pressure vessel (12) becomes a low-pollution waste container.

[0060]

Figure 5 is a diagram illustrating the operation procedure of removal of the heat shielding body in step S5 shown in Figure 1.

[0061]

As shown in Figure 5, in steps S51 and S52, air lock (5) of hoisting-up chamber (16) is opened, the open/close type lid device is opened, the hoisting fixture is mounted on the hook of crane (7) set on the ceiling surface of hoisting-up chamber (16) and is lowered in nuclear reactor building (1), the hoisting fixture is bound to heat shielding body (25), and heat shielding body (25) is cut off from pedestal (27). Upon the end of the cutting operation, crane (7) is used for hoisting into hoisting-up chamber (16), and air lock (5) is closed.

[0062]

Then, in step S53, air lock (4) is opened, flatcar (6) is driven from hoisting-out chamber (17) to hoisting-up chamber (16), heat shielding body (25) is lowered onto flatcar (6), the hoisting fixture is removed and curing is performed, flatcar (6) is driven to hoisting-out chamber (17), and air lock (4) is closed.

[0063]

Then, in step S54, air lock (3) on the ceiling of hoisting-out chamber (17) is opened, the hoisting fixture is mounted on the hook of tower crane (11) and is lowered to hoisting-out chamber (17), the hoisting fixture is bound to heat shielding body (25), nuclear reactor pressure vessel (12) is hoisted out from hoisting-out chamber (17), and it is lowered on running flatcar (13) running on the ground surface. After said running flatcar (13) is driven to operation chamber (19) of maintenance building (14), heat shielding body (25) is lowered from running flatcar (13) into operation pit (15) by ceiling running crane (20); it is disassembled by a cutter using a laser beam, and the disassembled pieces are packed in a drum can for storage at a waste-storing site (step S55).

[0064]

Figure 6 is a diagram illustrating the procedure of operation of installation of the new pressure vessel in step S6 shown in Figure 1. /8

[0065]

As shown in Figure 6, in step S61, the frame for shielding wall and the structural unit on factory-manufactured nuclear reactor pressure vessel (12) for replacement (the new nuclear reactor pressure vessel) is moved by means of running flatcar (13)into the range that allows hoisting of tower crane (11); then the hoisting fixture mounted on the hook of said tower crane (11) is joined to nuclear sector pressure vessel (92), the frame of the heat shielding wall and the structural unit, it is hoisted and lowered from air lock (3) by the opening in the hoisting-out chamber (17) onto flatcar (6) within hoisting-out chamber (17). In this way nuclear reactor pressure vessel (12) for replacement is taken from running flatcar (13) into nuclear reactor building (1) (step S62). Then, the aforementioned hoisting fixture is removed and the hook of tower crane (11) is hoisted out from hoisting-out chamber (17).

[0066]

After air lock (3) is closed, air lock (4) is opened, and flatcar (6) is driven from hoisting-out chamber (17) to hoisting-up chamber (16). The hoisting fixture mounted on the hook of crane (7) set on the ceiling surface of said hoisting-up chamber (16) is bound to nuclear reactor pressure vessel (12), the frame for the heat shielding wall, and the structural unit for replacement. After minor lifting, flatcar (6) is moved from hoisting-up chamber (16) to hoisting-out chamber (17).

[0067]

Then, air lock (4) is closed, air lock (5) and open/close type lid device is opened, and nuclear reactor pressure vessel (12), the frame for heat shielding wall and the structural unit for replacement hung from crane (7) are lowered into nuclear reactor building (1). Then, nuclear reactor pressure vessel (12), the frame for heat shielding wall, and the structural unit for replacement are lowered onto pedestal (27), and they are fixated (step S63). Upon end of the fixating operation, the hoisting fixture is removed, the hook of crane (7) is pulled up into hoisting-up chamber (16), and air lock (5) and open/close type lid device is closed (step S64). Then, accommodating equipment (8) and tower crane (11) are withdrawn from frame (2). Then, frame is disassembled and withdrawn.

[0068]

Figure 7 is a diagram illustrating the procedure of operation for binding the various members to the nuclear reactor pressure vessel in step S8 as shown in Figure 1. As shown in Figure 7, in step S71 the pipeline is connected by welding to the nozzle of nuclear reactor pressure vessel (12) for replacement, and concrete for heat shielding is formed on the frame for heat shielding wall and structural unit. Then, in step S72 the sealing member between nuclear reactor pressure vessel (12) and the nuclear reactor accommodating container is connected to the sealing bellows. In step S73, control rod driving mechanism (CRD) is mounted on nuclear reactor pressure vessel (12), and, finally, in step S74 a pressure resistance test of nuclear reactor pressure vessel (12) is carried out.

[0069]

Figure 8 is a diagram illustrating the procedure of operation for withdrawing the equipment for removing the nuclear reactor pressure vessel in step S9 shown in Figure 1. As shown in Figure 8, after opening portion (10) of roof (9) of nuclear reactor building (1) is closed by the lid in step S81, the air tight seal between roof (9) of nuclear reactor building (1) and the equipment for removing nuclear reactor pressure vessel (12) is released in step S82. That is, in step S82, the air tight seal between the lower surface of hoisting-up chamber (16) and roof (9) of nuclear reactor building (1) is released. Then, in step S83, the removal equipment, such as wire, etc., for nuclear reactor pressure vessel (12) is withdrawn from above roof (9) of nuclear reactor building (1).

[0070]

Figure 9 is a diagram illustrating the procedure of fuel reloading in step S10 in Figure 1. As shown in Figure 9, after the upper lid of nuclear reactor pressure vessel (12) is removed in

step S91, the internal structural members are removed from nuclear reactor pressure vessel (12) in step S92, and temporarily set inside the nuclear reactor pit. Then, water is filled in nuclear reactor well (26), and the used fuel is transported from fuel storing pit (23) of fuel storing chamber (21) in maintenance building (14) through a fuel transporting route to the fuel storing rack of fuel storing pool (22) for accommodating in the fuel transporting container (step S93).

[0071]

Then, in step S94, fuel is loaded from said fuel storing rack into the core of the nuclear reactor by a fuel handler. Then, upon end of loading of the fuel and loading of the control rods, in step S95, the internal structural members are mounted in nuclear reactor pressure vessel (12). In step S96, the upper lid is mounted on nuclear reactor pressure vessel (12). Then, in step S97, the head portion of the nuclear reactor accommodating container is installed, and the replacement operation of nuclear reactor pressure vessel (12) ends.

[0072]

In Application Example 1, by using frame (2) straddling nuclear reactor building (1), accommodating equipment (8) for removing and accommodating nuclear reactor pressure vessel (12) carried on said frame, tower crane (11), running flatcar (13) that runs on the ground surface, maintenance building (14) for performing disassembly, cleaning of pollution, dissection, repair, maintenance operation, etc. for nuclear reactor pressure vessel (12), etc., it is possible to perform replacement of nuclear reactor pressure vessel (12) in a short time free of diffusion of the radioactive substances to the surrounding environment, and it is possible to safely keep the replaced large-sized structural members for a long time.

[0073]

In Application Example 1, tower crane (11) is carried on frame (2). However, the configuration is not limited to that. It is also possible to set the tower crane and crawler crane (30) (see Figure 12) on the ground surface. It is also possible to realize the same effect as in Application Example 1 by means of these cranes.

[0074]

Also, in the of formation of the opening on roof (9) of nuclear reactor building (1), a cutter using a laser beam or the like is used. In this case, examples of the lasers that may be used include a visible semiconductor laser, YAG laser, copper vapor laser, etc.

[0075]

Figure 11 is a diagram illustrating the configuration of a modified example of Application Example 1 of the device for replacement of the nuclear reactor pressure vessel in this invention.

[0076]

In this modified example, accommodating equipment (31) carried on frame (2) is made up only of hoisting-up chamber (16) of Application Example 1. In this modified example there is no need to perform the open/close operation of air lock (3) of hoisting-out chamber (17) as would be needed in Application Example 1, and it is thus possible to shorten the operational period needed for replacement of nuclear reactor pressure vessel (12).

[0077]

Application Example 2 (for the device)

Figure 12 is a diagram illustrating Application Example 2 of the device for replacement of nuclear reactor pressure vessel. The same part numbers as those in Application Example 1 are adopted here for Application Example 2. This is also true for the other application examples and modified examples to be presented below. /9

[0078]

Application Example 2 differs from Application Example 1 in that accommodating equipment (31) carried on frame (2) is comprised of hoisting-up chamber (16) alone. Said flatcar (6) has a structure that allows it to run from within hoisting-up chamber (16) to the end portion of frame (2). Also, tower crane or crawler crane (30) is set on the ground surface.

[0079]

This application example differs from Application Example 1 further in that it has the following function: after air lock (5) of hoisting-up chamber (16) is closed and air lock (4) is opened, nuclear reactor pressure vessel (12) is transported on flatcar (6); then, flatcar (6) is driven from within hoisting-up chamber (16) to the end portion of frame (2) to transport nuclear reactor pressure vessel (12), etc.

[0080]

The effects of the device in Application Example 2 are the same as those in Application Example 1. However, in this case the open/close operation of air lock (3) of hoisting-out chamber (17), as would be needed in Application Example 1, is not needed. Consequently, the

operation period can be shortened. Also, as flatcar (6) is driven to the end portion of frame (2) to transport nuclear reactor pressure vessel (12) or the like, it is possible to reduce the operational range of tower crane or crawler crane (30), and it is possible to reduce the size of the equipment needed. The other structural features, operational features, and effects are the same as those in Application Example 1 and will not be explained again. Also, for the application examples and modified examples to be presented below, the structure, function, and effects are also the same as those in Application Example 1, and they also will not be explained again.

[0081]

Also, in Application Example 2, if flatcar (6) is equipped with a pneumatic-float-type moving device, it is possible to make the movement in a pneumatic floating state. It is thus possible to transport nuclear reactor pressure vessel (12) or the like while flatcar (6) floats over the floor of frame (2) and accommodating equipment (31). As a result, the power needed for driving flatcar (6) can be reduced, flatcar (6) can be made lighter, and the structure of frame (2) can be made smaller. In this case, the aforementioned pneumatic-floating-type moving device makes use of pneumatic pressure to inflate a diaphragm to form a pressure region such that a thin air film is formed between the diaphragm and the floor surface while the control air leaks to the atmosphere. By means of this air film, the workpiece can be lifted so that there is no friction between the workpiece and the floor. Consequently, only a small force can drive the flatcar to move in any direction.

[0082]

Application Example 3 (for the device)

Figure 13 is a diagram illustrating the configuration of Application Example 3 of the device for replacement of nuclear reactor pressure vessel in this invention. In Application Example 3, the accommodating equipment carried on frame (2) is made up of a hoisting-up chamber alone. This hoisting-up chamber is comprised of air dome (31). Also, flatcar (6) can run from one end portion to the other end portion of frame (2), and it can move in the pneumatic floating state on frame (2) and on the floor of hoisting-up chamber (16) of accommodating equipment (33) just as in the modified example of Application Example 2. In addition, gantry structural body (32) is set on frame (2), and crane (7) for hoisting nuclear reactor pressure vessel (12) or the like is mounted on said gantry structural body (32). The entirety of gantry structural body (32) is surrounded by air dome (31). Air locks (34) and (35) are set on the side surface of lower surface of said air dome (31) to form the hoisting-up chamber. Crawler crane (30) is set on the ground surface.

[0083]

The functions of Application Example 3 are similar to the functions of Application Example 2. However, this application example differs from Application Example 2 in that it has the following function: after air lock (35) of air dome (31) is closed and air lock (34) is opened, nuclear reactor pressure vessel (12) or the like carried on flatcar (6) is moved from within air dome (31) to the end portion of frame (2), and flatcar (6) is floated by pneumatic pressure to transport nuclear reactor pressure vessel (12) or the like.

[0084]

In Application Example 3 of the device, the hoisting-up chamber is made up of air dome (31). Consequently, handling is simple, the device is light, and the structure of frame (2) can be made small.

[0085]

Application Example 4 (for device)

Figure 14 is a diagram illustrating the structure of the main portion of Application Example 4 of the device for replacement of nuclear reactor pressure vessel in this invention. In Application Example 4, the frame is gantry crane (36) instead of frame (2) in Application Example 1. With nuclear reactor pressure vessel (12) hoisted in accommodating equipment (33), said gantry crane (36) runs on guide rail (37), and nuclear reactor pressure vessel (12) is directly lifted and lowered onto running flatcar (13). Also, accommodating equipment (33) that forms hoisting-up chamber (16) is carried on gantry crane (36), and gantry structural body (32) with crane (7) mounted on it is set in air dome (31).

[0086]

In the following, the function of Application Example 4 will be explained.

[0087]

In order to enable gantry crane (36) straddling on nuclear reactor building (1) to run, guide rail (37) is laid along nuclear reactor building (1). On said guide rail (37), gantry crane (36) is assembled at a position that straddles nuclear reactor building (1). Upon end of the assembly operation, gantry crane (36) is driven to move such that the center of air lock (35) formed on the lower surface of hoisting-up chamber (16) is positioned right above the central axis of nuclear reactor pressure vessel (12) set in nuclear reactor building (1). Then, air lock (35) is opened, and the lower surface of hoisting-up chamber (16) and roof (9) of nuclear reactor building (1) are connected to each other with an air tight seal.

[0088]

Then, a hoisting fixture is mounted at the center of roof (9) corresponding to air lock (35). While crane (7) mounted on gantry structural body (32) of hoisting-up chamber (16) and said hoisting fixture are hoisted by wires, a block having a size matching the opening of air lock (35) is cut out from roof (9) by a cutter using a laser beam. Upon the end of the operation of cutting of the block of a size that allows passage of nuclear reactor pressure vessel (12) from roof (9), the block is lifted by crane (7) in hoisting-up chamber (16). Then, opening portion (10) on roof (9) is closed by a lid with an air cushion structure. The lower surface of hoisting-up chamber (16) and roof (9) of nuclear reactor building (1) is released, and air lock (35) is closed.

[0089]

Then, gantry crane (36) is driven to move above running flatcar (13) that runs on the ground surface, and the block is lowered on the running flatcar (13). Then, running flatcar (13) is driven to operation chamber (19) inside maintenance building (14). Using ceiling running crane (20), the block of roof (9) that has been cut out is lowered from running flatcar (13) into operation pit (15) or the like. Said block is disassembled by a cutter using a laser beam or the like, and the pieces obtained are packed in a drum can for storage at a waste-storing site. Then, in the same operation as in Application Example 1, nuclear reactor pressure vessel (12) and heat shielding body (25) are carried out. On the other hand, the operation for installing the new nuclear reactor pressure vessel is carried out in a procedure reverse to the aforementioned one. /10

[0090]

According to Application Example 4 of the device, gantry crane (36) runs on guide rail (37), and nuclear reactor pressure vessel (12) or the like is directly lowered onto running flatcar (13) and is carried on it. Consequently, tower crane (11) used in Application Example 1 is not needed in this case and, as gantry crane (36) can be assembled at a site where nuclear reactor building (1) is absent, the assembly operation can be carried out easily and the operational efficiency can be increased.

[0091]

Application Example 5 (for the device)

Figure 15 is a diagram illustrating the configuration of Application Example 5 of the device for nuclear reactor pressure vessel in this invention.

[0092]

In Application Example 5, frame (2) used in Application Example 1 is not used. Instead, crawler crane (30) is set on the ground surface. By means of crane (30), nuclear reactor pressure vessel (12) is hoisted into simple accommodating equipment (38), and nuclear reactor pressure vessel (12) is lowered directly onto running flatcar (13) and is carried on it. Also, simple accommodating equipment (38) has the function of the air dome.

[0093]

In the following, the function of Application Example 5 will be explained.

[0094]

This application example differs from Application Example 1 in which frame (2) and accommodating equipment (8) are used and opening portion (10) is formed on roof (9) of nuclear reactor building (1), in that simple accommodating equipment (38) is hoisted by crawler crane (30) and is bound on roof (9), and air is injected into simple accommodating equipment (38) to make it stand alone. Then, the hoisting fixture of crawler crane (30) is lowered in simple accommodating equipment (38); this hoisting fixture and the hoisting fixture mounted on roof (9) are bound to each other by wires. Then, in the same way as in Application Example 4, the cutting operation is carried out and simple lid (39) is mounted on opening portion (10). On simple lid (39), the binding mechanism with simple accommodating equipment (38) and a foldable open/close mechanism are attached. Also, in order to facilitate handling, an air cushion structure is adopted. Consequently, by making simple lid (39) and simple accommodating equipment (38) bound to each other and separated from each other, the operation of removal of nuclear reactor pressure vessel (12) and heat shielding body (25) and installation of the new nuclear reactor pressure vessel is carried out by crawler crane (30).

[0095]

In Application Example 5 of the device with the aforementioned configuration, binding/separation of simple lid (39) and simple accommodating equipment (38) are carried out by crawler crane (30), and nuclear reactor pressure vessel (12) and heat shielding body (25) are removed directly from nuclear reactor building (1). Consequently, there is no need to have equipment for hoisting nuclear reactor pressure vessel (12) using frame (2), and it is thus possible to cut the cost of equipment and to shorten the period of setup preparation for the equipment.

[0096]

Application Example 2 (for the method)

Figure 16 is a flow chart illustrating the procedure of operation of Application Example 2 of the method for replacement of nuclear reactor pressure vessel in this invention.

[0097]

With regard to Figure 16, the same operation steps as those shown in Figure 1 will not be explained again. That is, the operation steps P1-P5 and P8-P11 shown in Figure 16 are the same as their counterparts in Figure 1, and will not be explained again.

[0098]

Application Example 2 differs from Application Example 1, in which the new heat shielding body is assembled inside nuclear reactor building (1), in that the inner diameter of the new heat shielding body is selected to be larger than the outer diameter of the tip of the nozzle of the new nuclear reactor pressure vessel, and the new heat shielding body is installed as a single body.

[0099]

As shown in Figure 16, in step P6, the new heat shielding body as a single body is lowered through opening portion (10) on roof (9) of nuclear reactor building (1) and is fixated on pedestal (27). Then, in the same way in step P7, the new nuclear reactor pressure vessel is installed through opening portion (10) on roof (9) of nuclear reactor building (1) inserted in said new heat shielding body, and fixated on pedestal (27).

[0100]

In Application Example 2 of the method, in addition to the effects of said Application Example 1, there is also the following effect: the new heat shielding body as a single body is lowered into nuclear reactor building (1) for installation. Consequently, the operation period can be further shortened.

[0101]

Also, in this application example one may swap the order in installing the new heat shielding body and the new nuclear reactor pressure vessel into nuclear reactor building (1). The effect is the same.

[0102]

Application Example 3 (for the method)

Figure 17 is a flow chart illustrating the procedure of operation of Application Example 3 of the method for replacement of the nuclear reactor pressure vessel in this invention.

[0103]

The operation steps shown in Figure 17 are identical to those in Figure 1 and will not be explained again. This rule is also observed in the later application examples.

[0104]

In Application Example 3, the operation steps of removing the control rod driving device's handler, remodeling of the pedestal, and installation of the new internal pump/control rod driving device's handler are added to the steps in Application Example 1 while the assembly step of the new heat shielding body is deleted. In this application example, the new nuclear reactor pressure vessel corresponds to the internal pump and hence there is no need to set the heat shielding body.

[0105]

As shown in Figure 17, in step P25, heat shielding body (25) is removed. Then, in step P26, the control rod driving device's handler is removed. Then, in step P27, pedestal (27) is remodeled to be able to handle the internal pump. After that, in step P28, the new internal pump/control rod driving device's handler are installed, and, in step P29, the new nuclear reactor pressure vessel with the internal pump mounted on it is installed.

[0106]

In Application Example 3 of this invention, it is possible to change to a circulating system utilizing an internal pump for better safety, and it is possible to shorten the fuel exchange period. Also, it is possible to change to a core adopting a large-size fuel and, at the same time, to improve the safety and operation efficiency of the nuclear plant. /1

[0107]

Application Example 4 (for the method)

Figure 18 is a flow chart illustrating the procedure of operation in Application Example 4 of the method for replacement of the nuclear reactor pressure vessel in this invention.

[0108]

In Application Example 4, the operation of removal of the heat shielding body and assembly of the new heat shielding body is deleted from the operation procedure in Application Example 1. The nuclear reactor pressure vessel adopted in this application example is of a type corresponding to a circulating system by means of an internal pump.

[0109]

In Application Example 4 of this invention, it is possible to improve the safety and economy by adopting changes corresponding to an increase in the efficiency of the internal pump.

[0110]

Application Example 5 (for the method)

Figure 19 is a flow chart illustrating the procedure of operation in Application Example 5 of the method for replacement of the nuclear reactor pressure vessel in this invention.

[0111]

In Application Example 5, with respect to the operation procedure of Application Example 1, the operation of removal of the internal pump/control rod driving device's handler and installation of the new internal pump/control rod driving device's handler is added. On the other hand, the operation of removal of the heat shielding body and assembly of the new heat shielding body is deleted. Also, as nuclear reactor pressure vessel (12) corresponds to the internal pump, there is no need to set the heat shielding body.

[0112]

As shown in Figure 19, in step P54, nuclear reactor pressure vessel (12) is removed. Then, in step P55, the internal pump/control rod driving device's handler is removed. In step P56, the new internal pump/control rod driving device's handler is installed. Then, in step P57, the new nuclear reactor pressure vessel is taken in.

[0113]

In Application Example 4 of the method, both the effects of Application Example 1 and Application Example 3 can be realized.

[0114]

Application Example 6 (for the method)

Figure 20 is a flow chart illustrating the procedure of operation in Application Example 6 of the method for replacement of the nuclear reactor pressure vessel in this invention.

[0115]

In Application Example 6, from the operation procedure in Application Example 1, the operation of setting opening portion (10) on roof (9), the operation of removal of heat shielding body (25), and the operation of assembly of the new heat shielding body are deleted. Also, as nuclear reactor pressure vessel (12) corresponds to the internal pump, there is no need to set the heat shielding body. Also, as opening portion (10) on roof (9) is formed when the nuclear reactor is constructed, there is no step of formation of the opening.

[0116]

In Application Example 6 of the method with the aforementioned configuration, as there is no need to form opening portion (10) on roof (9), it is possible to reduce the number of steps of operation, and it is possible to shorten the operation period.

[0117]

Effect of the invention

According to the method for replacement of nuclear reactor pressure vessel described in Claim 1 of this invention, after the fuel and inner structural parts are removed from the nuclear reactor pressure vessel and transferred to a maintenance building for storage, equipment for removing the nuclear reactor pressure vessel is set above the nuclear reactor building; an opening is formed on the roof of the nuclear reactor building; from the opening, said nuclear reactor pressure vessel is removed; on the other hand, a new nuclear reactor pressure vessel is installed through the opening of said roof; then, the fuel and inner structural parts are transferred from said maintenance building back into the nuclear reactor pressure vessel for reloading. Consequently, the nuclear reactor pressure vessel can be replaced in a short time free of diffusion of the radioactive substance to the surrounding [area], and after replacement the large structural members can be safely stored for a long time.

[0118]

According to the method for replacement of nuclear reactor pressure vessel described in Claim 2, the pressure vessel and heat shielding body of the nuclear reactor are sequentially removed from the opening; on the other hand, a new heat shielding body and a new nuclear

reactor pressure vessel are installed through the opening of said roof. Consequently, it is possible to replace the nuclear reactor pressure vessel and heat shielding body in a short time free of diffusion of the radioactive substance to the surrounding [area].

[0119]

According to the method for replacement of nuclear reactor pressure vessel described in Claim 3, for the method described in Claim 2, the inner diameter of the new heat shielding body is selected to be larger than the outer diameter of the nozzle portion of the new nuclear reactor pressure vessel. Consequently, it is possible to further shorten the time of operation for lowering the new heat shielding body as a single body into the nuclear reactor building for replacement.

[0120]

According to the method for replacement of nuclear reactor pressure vessel described in Claim 4, for the method described in Claim 1, after the nuclear reactor pressure vessel is removed, the control rod driving device's handler is removed from the opening on the roof; then, the pedestal is remodeled, and a new internal pump/control rod driving device's handler is installed through the opening on said roof. Consequently, it is possible to change to a circulating system utilizing an internal pump with even higher safety, and it is possible to shorten the fuel exchange period. Also, it allows a change to a nuclear reactor adopting a larger fuel size, and it is possible to improve the safety and operational efficiency of the nuclear power plant.

[0121]

According to the method for replacement of nuclear reactor pressure vessel described in Claim 5, for the method described in Claim 1, the nuclear reactor pressure vessel is of a type corresponding to a circulating system utilizing an internal pump. Consequently, it is possible to perform the change needed for increasing the efficiency of the internal pump so that safety and economy can be improved.

[0122]

According to the method for replacement of nuclear reactor pressure vessel described in Claim 6, for the method described in Claim 1, after the nuclear reactor pressure vessel is removed, the internal pump/control rod driving device's handler is removed from the opening on the roof; then, a new internal pump/control rod driving device's handler is installed through the opening on said roof. In this way the functions described in both Claim 1 and 4 can be realized.

[0123]

According to the method for replacement of nuclear reactor pressure vessel described in Claim 7, after the fuel and inner structural parts are removed from the nuclear reactor pressure vessel and transferred to a maintenance building for storage, equipment for removing the nuclear reactor pressure vessel is set above the nuclear reactor building; from an opening formed beforehand on the roof of the nuclear reactor, said nuclear reactor pressure vessel is removed; on the other hand, a new nuclear reactor pressure vessel is installed through the opening of said roof; then, the fuel and inner structural parts are transferred from said maintenance building back into the nuclear reactor pressure vessel for reloading. Consequently, in the replacement operation there is no need to set an opening portion on the roof of the nuclear reactor building. As a result, the number of operation steps is reduced and the operation period is shortened.

[0124]

According to the device for replacement of nuclear reactor pressure vessel described in /12
Claim 8, the device has the following parts: a frame set straddling the nuclear reactor building, accommodating equipment which is carried on the frame and which is connected by a third air lock to a removal chamber with a first air lock mounted on the upper side and a hoisting-up chamber with a second air lock mounted on the lower side, a crane which is set on the ceiling surface of said hoisting-up chamber and which hoists the nuclear reactor pressure vessel from said nuclear reactor building to the hoisting-up chamber, a flatcar which moves on the floor of said removal chamber and hoisting-up chamber, a tower crane which is carried on said frame and which lowers the nuclear reactor pressure vessel transferred to said removal chamber to outside said accommodating equipment, and a running flatcar which runs to transfer the nuclear reactor pressure vessel lowered by said tower crane to the maintenance building; while the nuclear reactor pressure vessel is removed from said nuclear reactor building to the maintenance building for disassembly, cleaning of pollution, repair, and storage, a new nuclear reactor pressure vessel for replacement is lowered and installed in said nuclear reactor building. Consequently, when the nuclear reactor pressure vessel is taken into/from the nuclear reactor building as a single body, there is no need to give special consideration to reinforcement of the nuclear reactor building. It is possible to prevent emission of the radioactive substance from the nuclear reactor building, and the exposure to radiation during operation can be reduced.

[0125]

According to the device for replacement of nuclear reactor pressure vessel described in Claim 9, for the device described in Claim 8, the accommodating equipment is made up of a hoisting-up chamber alone. Consequently, there is no need to perform the operation for

opening/closing the first air lock of the hoisting-out chamber, and the operation period needed for replacement of the nuclear reactor pressure vessel can be shortened.

[0126]

According to the device for replacement of nuclear reactor pressure vessel described in Claim 10, for the device described in Claim 8, the accommodating equipment is made of a hoisting-up chamber alone, and the tower crane is changed to a frame set on the ground surface. Consequently, in addition to the function of Claim 9, the operation for setting the tower crane becomes easier.

[0127]

According to the device for replacement of nuclear reactor pressure vessel described in Claim 11, for the device described in Claim 10, a crawler crane is used instead of the tower crane. Consequently, the same function as Claim 10 can be realized.

[0128]

According to the device for replacement of nuclear reactor pressure vessel described in Claim 12, for the device described in Claim 8, the accommodating equipment is made of a hoisting-up chamber alone, and the flatcar has a structure that allows it to move from one end of the frame to the other end. Consequently, in addition to the function of Claim 9, the operation range of the tower crane can be made narrower and the size of the equipment needed can be reduced.

[0129]

According to the device for replacement of nuclear reactor pressure vessel described in Claim 13, for the device described in Claim 8 or 12, the flatcar moving on the frame is equipped with a pneumatic float-up-type moving device. Consequently, movement of the flatcar becomes easier.

[0130]

According to the device for replacement of nuclear reactor pressure vessel described in Claim 14, for the device described in Claim 12, the hoisting-up chamber has an air dome structure; a gantry structural body is set inside it; and the crane for hoisting the nuclear reactor pressure vessel is mounted on the gantry structural body. Consequently, handling becomes simpler, the system becomes lighter, and the frame becomes smaller.

[0131]

According to the device for replacement of nuclear reactor pressure vessel described in Claim 15, for the device described in Claim 8 or 14, the frame is of a running type, and the nuclear reactor pressure vessel is carried directly on the running flatcar by a crane mounted on the gantry structural body.

[0132]

According to the device for replacement of nuclear reactor pressure vessel described in Claim 16, the device has the following parts: a crawler crane which hoists the nuclear reactor pressure vessel from a nuclear reactor building set on the ground surface, a simple accommodating equipment which is set in said nuclear reactor building and has the nuclear reactor pressure vessel hoisted into it, and a running flatcar which directly carries the simple accommodating equipment with the nuclear reactor pressure vessel joined to it by said crawler crane from the nuclear reactor building and transfers it to the maintenance building; while the nuclear reactor pressure vessel is removed from said nuclear reactor building to the maintenance building for disassembly, cleaning of pollution, repair, and storage, a new nuclear reactor pressure vessel for replacement is lowered and installed in said nuclear reactor building. Consequently, the nuclear reactor pressure vessel can be removed directly from the nuclear reactor building, and there is thus no need to have equipment for hoisting and moving the nuclear reactor pressure vessel by means of the frame. As a result, the operation preparation period for constructing the equipment can be cut.

Brief description of the figures

Figure 1 is a flow chart illustrating the procedure of operation of Application Example 1 of the method for replacement of the nuclear reactor pressure vessel in this invention.

Figure 2 is a flow chart illustrating the procedure of operation for preparing removal of the nuclear reactor pressure vessel in step S2 shown in Figure 1.

Figure 3 is a flow chart illustrating the procedure of operation for the formation of an opening on the roof of the nuclear reactor building in step S3 shown in Figure 1.

Figure 4 is a flow chart illustrating the procedure of operation for removal of the nuclear reactor pressure vessel in step S4 shown in Figure 1.

Figure 5 is a flow chart illustrating the procedure of operation for removal of the heat shielding body in step S5 shown in Figure 1.

Figure 6 is a flow chart illustrating the procedure of operation for removal of the new pressure vessel in step S6 in Figure 1.

Figure 7 is a flow chart illustrating the procedure of operation for binding the various members in the nuclear reactor pressure vessel in step S8 shown in Figure 1.

Figure 8 is a flow chart illustrating the procedure of operation for withdrawing the equipment for removal of the nuclear reactor pressure vessel in step S9 shown in Figure 1.

Figure 9 is a flow chart illustrating the procedure of operation for reloading of fuel in step S10 shown in Figure 1.

Figure 10 is a diagram illustrating the configuration of Application Example 1 of the device for replacement of nuclear reactor pressure vessel in this invention.

Figure 11 is a diagram illustrating the configuration of a modified example of Application Example 1 of the device for replacement of nuclear reactor pressure vessel in this invention.

Figure 12 is a diagram illustrating the configuration of Application Example 2 of the device for replacement of nuclear reactor pressure vessel in this invention.

Figure 13 is a diagram illustrating the configuration of Application Example 3 of the device for replacement of nuclear reactor pressure vessel in this invention.

Figure 14 is a diagram illustrating the configuration of Application Example 4 of the device for replacement of nuclear reactor pressure vessel in this invention.

Figure 15 is a diagram illustrating the configuration of Application Example 5 of the device for replacement of nuclear reactor pressure vessel in this invention.

Figure 16 is a flow chart illustrating the procedure of operation in Application Example 2 of the method for replacement of nuclear reactor pressure vessel in this invention.

Figure 17 is a flow chart illustrating the procedure of operation in Application Example 3 of the method for replacement of nuclear reactor pressure vessel in this invention.

Figure 18 is a flow chart illustrating the procedure of operation in Application Example 4 of the method for replacement of nuclear reactor pressure vessel in this invention.

Figure 19 is a flow chart illustrating the procedure of operation in Application Example 5 of the method for replacement of nuclear reactor pressure vessel in this invention.

Figure 20 is a flow chart illustrating the procedure of operation in Application Example 6 of the method for replacement of nuclear reactor pressure vessel in this invention.

Brief explanation of symbols

1 Nuclear reactor building
2 Frame
3 Air lock (first air lock)
4 Air lock (third air lock)
5 Air lock (second air lock)

6 Flatcar
7 Crane
8 Accommodating equipment
9 Roof
10 Opening portion
11 Tower crane
12 Nuclear reactor pressure vessel
13 Running flatcar
14 Maintenance building
15 Operation pit
16 Hoisting-up chamber
17 Hoisting-out chamber
19 Operation chamber
20 Ceiling running crane
21 Fuel storing chamber
22 Fuel storing pool
23 Fuel storing pit
24 Ceiling crane
25 Heat shielding body
26 Nuclear reactor well
27 Pedestal
28 Operation pit
29 Water gate
30 Crawler crane
31 Air dome
32 Gantry structural body
33 Accommodating equipment
34, 35 Air lock
36 Gantry crane
37 Guide rail
38 Simple accommodating equipment
39 Simple lid

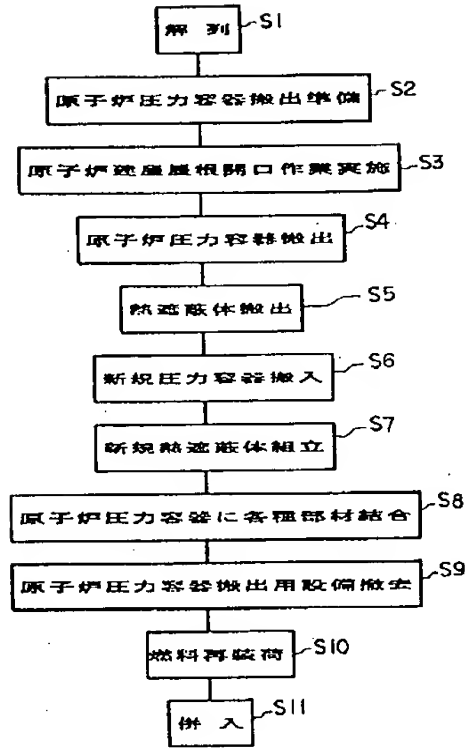

Figure 1

Key:
S1 Shut-down of nuclear reactor
S2 Preparation of removal of nuclear reactor pressure vessel
S3 Embodiment of operation for forming opening on roof of nuclear reactor building
S4 Removal of nuclear reactor pressure vessel
S5 Removal of heat shielding body
S6 Installation of new pressure vessel
S7 Assembly of new heat shielding body
S8 Binding of various members to nuclear reactor pressure vessel
S9 Withdrawal of equipment for removal of nuclear reactor pressure vessel
S10 Reloading of fuel
S11 Restart of nuclear reactor

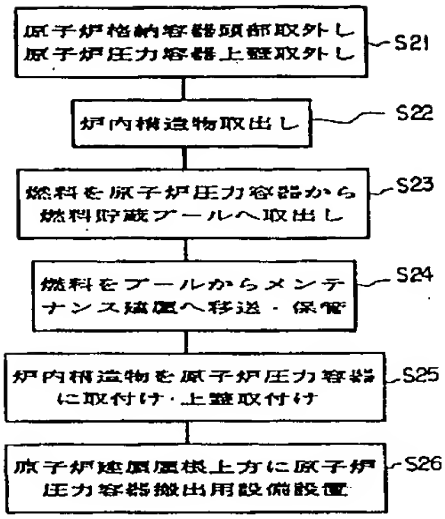

Figure 2. Preparation of removal of nuclear reactor pressure vessel

Key: S21 Removal of head portion of nuclear reactor accommodating container; removal of upper lid of nuclear reactor pressure vessel
S22 Removal of internal structural members
S23 Removal of fuel from nuclear reactor pressure vessel to fuel storing pool
S24 Transporting of fuel from pool to maintenance building for storage
S25 Mounting of internal structural members on nuclear reactor pressure vessel; mounting of upper lid
S26 Setting of equipment for removal of nuclear reactor pressure vessel above roof of nuclear reactor building

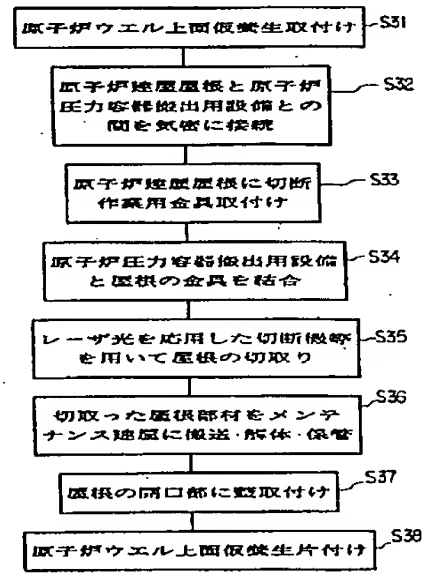

Figure 3. Embodiment of the operation for forming opening on roof of nuclear reactor building

Key: S31 Setup for temporary curing of upper surface of nuclear reactor well
S32 Connecting of roof of nuclear reactor building to equipment for removal of nuclear reactor pressure vessel in air tight state
S33 Installation of fixture for cutting operation on roof of nuclear reactor building
S34 Binding of equipment for removal of nuclear reactor pressure vessel to fixture of roof
S35 Cutting of a block of roof by a cutter using a laser beam or the like
S36 Transporting, disassembly and storage of cut block of roof to maintenance building
S37 Mounting of lid on opening portion of roof
S38 Setup for temporary curing of upper surface of nuclear reactor well

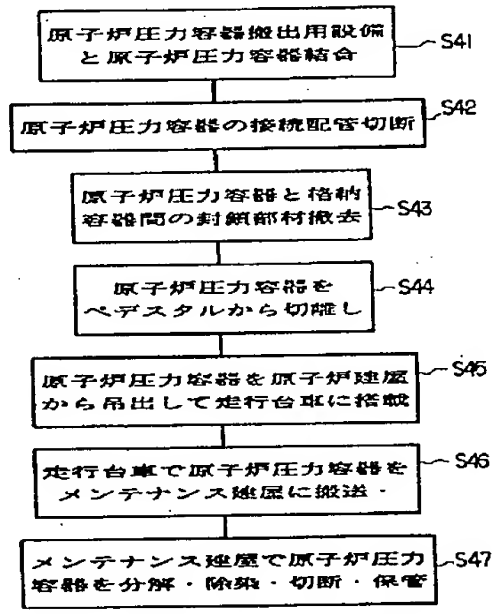

Figure 4. Removal of nuclear reactor pressure vessel

Key: S41 Binding of equipment for removal of nuclear reactor pressure vessel to nuclear reactor pressure vessel [sic]
S42 Cutting of connecting pipeline of nuclear reactor pressure vessel
S43 Withdrawal of blocking member between nuclear reactor pressure vessel and accommodating container
S44 Cutting of nuclear reactor pressure vessel from pedestal
S45 Hoisting of nuclear reactor pressure vessel from nuclear reactor building and carrying on running flatcar
S46 Transporting of nuclear reactor pressure vessel by running flatcar to maintenance building
S47 Disassembly, cleaning of pollution, dissection, cutting and storing of nuclear reactor pressure vessel in maintenance building

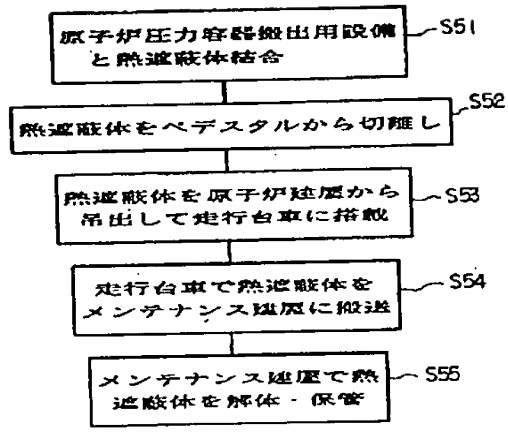

Figure 5. Removal of heat shielding body

Key: S51 Binding of equipment for removal of nuclear reactor pressure vessel to heat shielding body
S52 Cutting of heat shielding body from pedestal
S53 Hoisting of heat shielding body from nuclear reactor building and carrying it on running flatcar
S54 Transporting of heat shielding body to maintenance building by running flatcar
S55 Disassembly and storage of heat shielding body in maintenance building

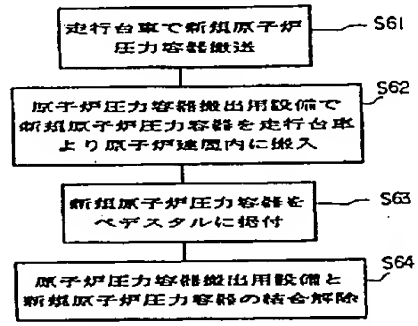

Figure 6. Installation of new pressure vessel

Key: S61 Installation of new nuclear reactor pressure vessel by running flatcar
S62 Installation of new nuclear reactor pressure vessel by running flatcar with the aid of equipment for removal of nuclear reactor pressure vessel
S63 Installation of new nuclear reactor pressure vessel on pedestal
S64 Releasing of binding between equipment for removal of nuclear reactor pressure vessel and new nuclear reactor pressure vessel

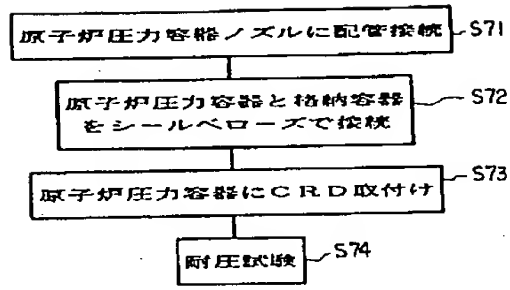

Figure 7. Binding of various members to nuclear reactor pressure vessel

Key: S71 Connection of pipeline to nozzle of nuclear reactor pressure vessel
S72 Connection of nuclear reactor pressure vessel and accommodating container by sealing bellows
S73 Mounting of CRD on nuclear reactor pressure vessel
S74 Pressure resistance test

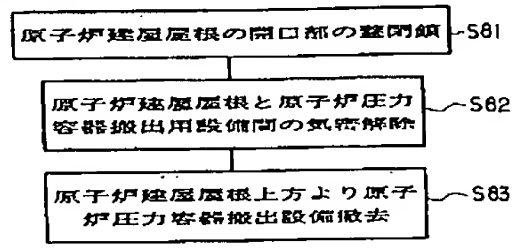

Figure 8. Withdrawal of equipment for removal of nuclear reactor pressure vessel

Key: S81 Closing of opening portion on roof of nuclear reactor building by lid
S82 Releasing of air tight state between roof of nuclear reactor building and equipment for removal of nuclear reactor pressure vessel
S83 Withdrawal of equipment for removal of nuclear reactor pressure vessel from above roof of nuclear reactor building

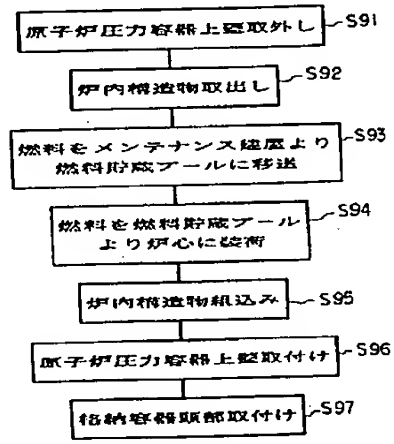

Figure 9. Reloading of fuel

Key:
- S91 Removal of upper lid nuclear reactor pressure vessel
- S92 Removal of internal structural members
- S93 Transporting of fuel from maintenance building to fuel storing pool
- S94 Loading of fuel from fuel storing pool to core of nuclear reactor
- S95 Assembly of internal structural members
- S96 Mounting of upper lid of nuclear reactor pressure vessel
- S97 Mounting of head portion of accommodating container

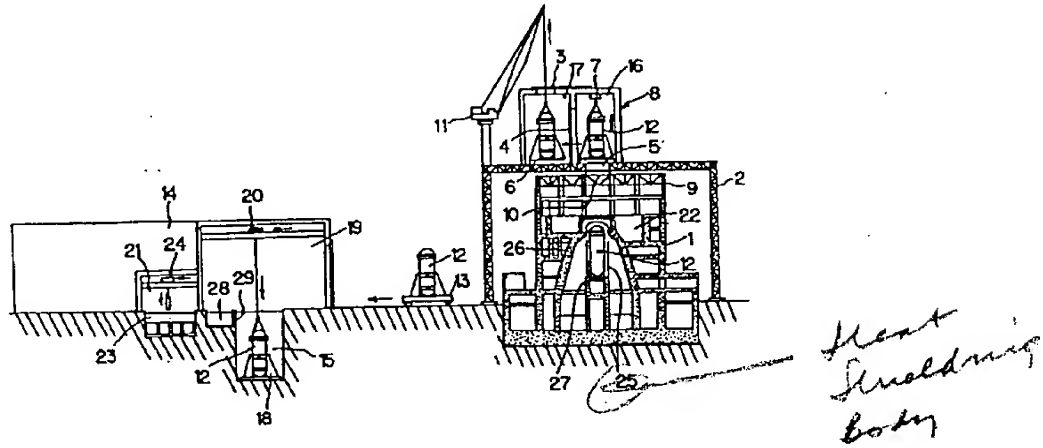

Figure 10

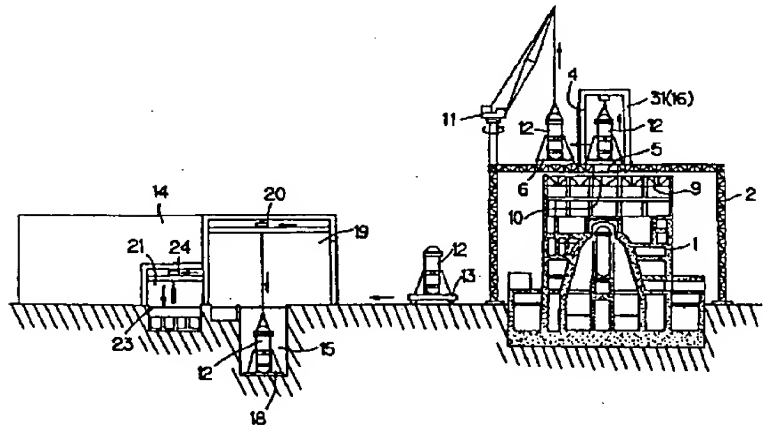

Figure 11

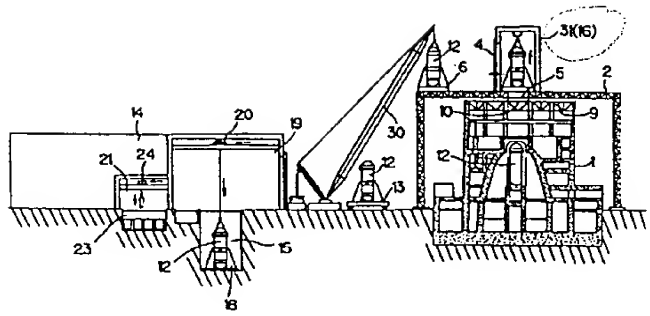

Figure 12

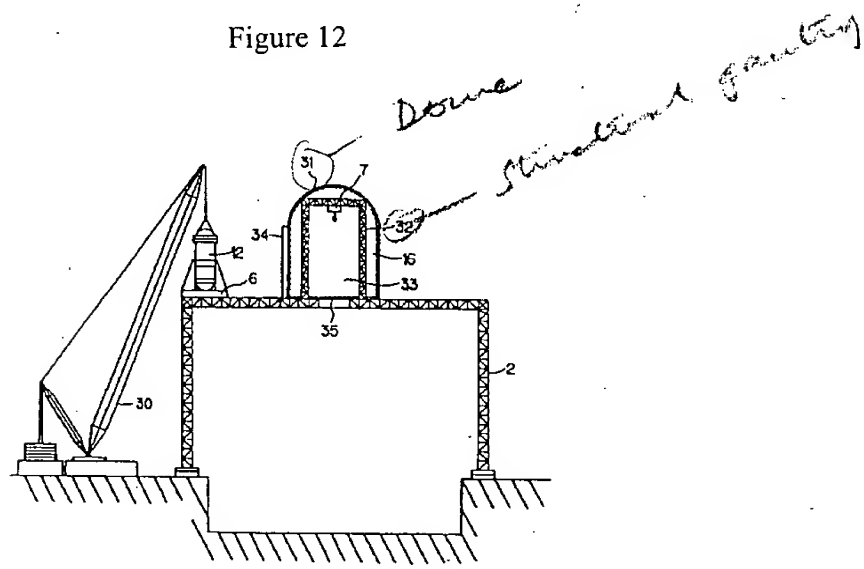

Figure 13

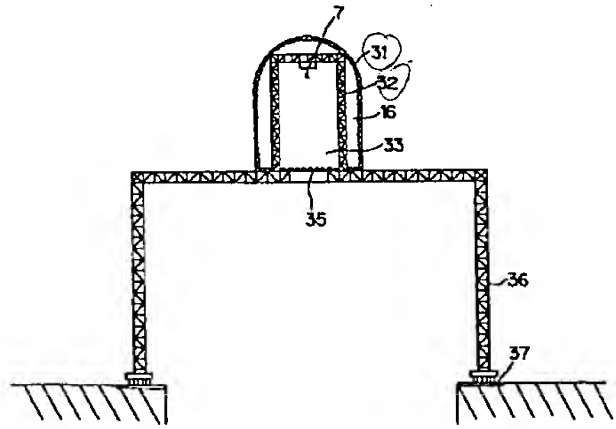

Figure 14

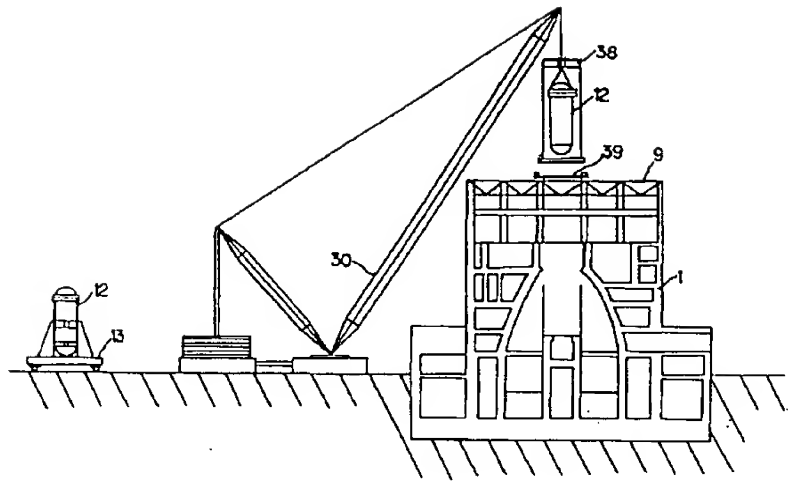

Figure 15

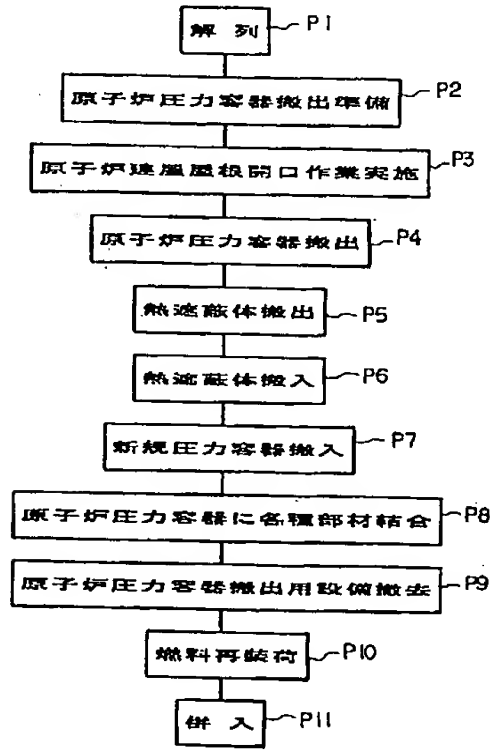

Figure 16

Key:
P1 Shut-down of nuclear reactor
P2 Preparation of removal of nuclear reactor pressure vessel
P3 Embodiment of operation for forming opening on roof of nuclear reactor building
P4 Removal of nuclear reactor pressure vessel
P5 Removal of heat shielding body
P6 Installation of heat shielding body

P7 Installation of new pressure vessel
P8 Binding of various members to nuclear reactor pressure vessel
P9 Withdrawal of equipment for removal of nuclear reactor pressure vessel
P10 Reloading of fuel
P11 Restart of nuclear reactor

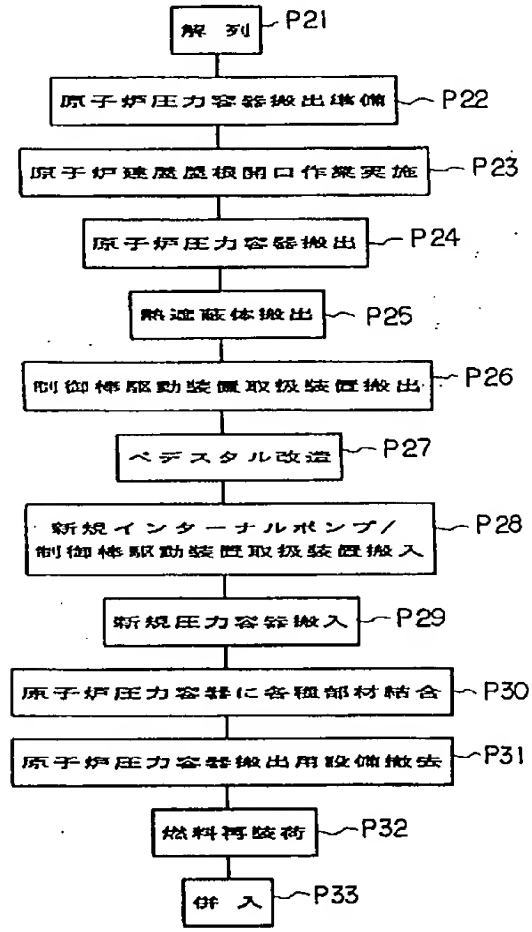

Figure 17

Key: P21 Shut-down of nuclear reactor
P22 Preparation of removal of nuclear reactor pressure vessel
P23 Embodiment of operation for forming opening on roof of nuclear reactor building
P24 Removal of nuclear reactor pressure vessel
P25 Removal of heat shielding body
P26 Removal of control rod driving device's handler
P27 Remodeling of pedestal
P28 Installation of new internal pump/control rod driving device's handler
P29 Installation of new pressure vessel
P30 Binding of various members to nuclear reactor pressure vessel

P31 Withdrawal of equipment for removal of nuclear reactor pressure vessel
P32 Reloading of fuel
P33 Restart of nuclear reactor

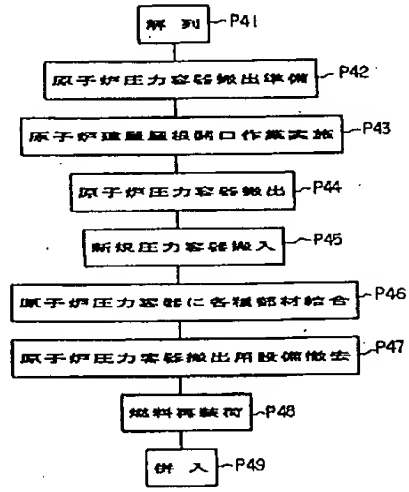

Figure 18

Key: P41 Shut-down of nuclear reactor
P42 Preparation of removal of nuclear reactor pressure vessel
P43 Embodiment of operation for forming opening on roof of nuclear reactor building
P44 Removal of nuclear reactor pressure vessel
P45 Installation of new pressure vessel
P46 Binding of various members to nuclear reactor pressure vessel
P47 Withdrawal of equipment for removal of nuclear reactor pressure vessel
P48 Reloading of fuel
P49 Restart of nuclear reactor

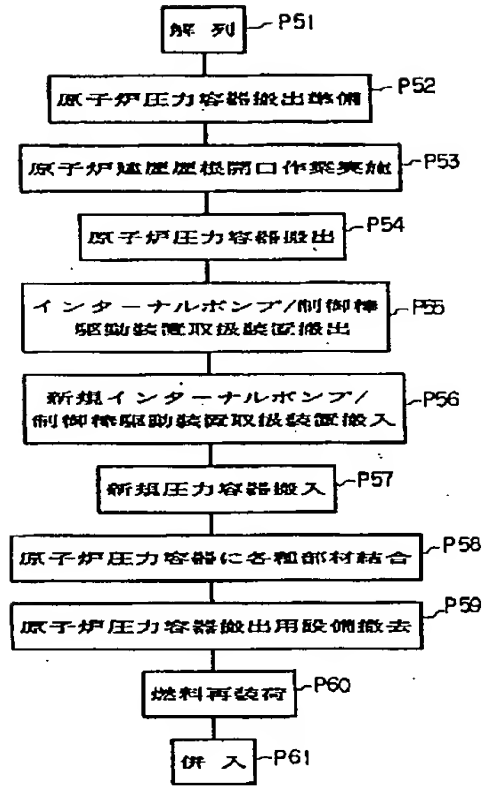

Figure 19

Key:
- P51 Shut-down of nuclear reactor
- P52 Preparation of removal of nuclear reactor pressure vessel
- P53 Embodiment of operation for forming opening on roof of nuclear reactor building
- P54 Removal of nuclear reactor pressure vessel
- P55 Removal of internal pump/control rod driving device's handler
- P56 Installation of new internal pump/control rod driving device's handler
- P57 Installation of new pressure vessel
- P58 Binding of various members to nuclear reactor pressure vessel
- P59 Withdrawal of equipment for removal of nuclear reactor pressure vessel
- P60 Reloading of fuel
- P61 Restart of nuclear reactor

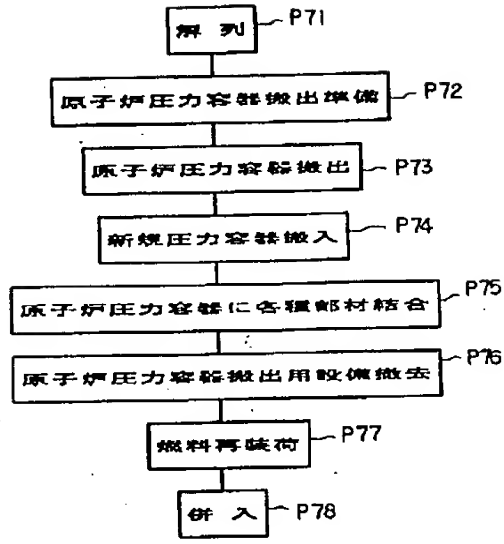

Figure 20

Key:
P71 Shut-down of nuclear reactor
P72 Preparation of removal of nuclear reactor pressure vessel
P73 Removal of nuclear reactor pressure vessel
P74 Installation of new pressure vessel
P75 Binding of various members.to nuclear reactor pressure vessel
P76 Withdrawal of equipment for removal of nuclear reactor pressure vessel
P77 Reloading of fuel
P78 Restart of nuclear reactor